NATIONAL BUREAU OF STANDARDS REPORT

6669

Development, Testing, and Evaluation of Visual Landing Aids
Consolidated Progress Report for the Period October 1 to December 31, 1959

By
Photometry and Colorimetry Section
Optics and Metrology Division

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

Functions and Activities

The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards: the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to government agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. Research projects are also performed for other government agencies when the work relates to and supplements the basic program of the Bureau or when the Bureau's unique competence is required. The scope of activities is suggested by the listing of divisions and sections on the inside of the back cover.

Publications

The results of the Bureau's work take the form of either actual equipment and devices or published papers. These papers appear either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau itself publishes three periodicals available from the Government Printing Office: The Journal of Research, published in four separate sections, presents complete scientific and technical papers; the Technical News Bulletin presents summary and preliminary reports on work in progress; and Basic Radio Propagation Predictions provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: Monographs, Applied Mathematics Series, Handbooks, Miscellaneous Publications, and Technical Notes.

Information on the Bureau's publications can be found in NBS Circular 460, Publications of the National Bureau of Standards ($1.25) and its Supplement ($1.50), available from the Superintendent of Documents, Government Printing Office, Washington 25, D.C.

NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT		NBS REPORT
0201-20-02411 0201-20-02414	February 1960	6669

Development, Testing, and Evaluation of Visual Landing Aids

Consolidated Progress Report
to
Ship Aeronautics Division
and
Meteorological Division
Bureau of Naval Weapons
Department of the Navy
Washington 25, D. C.

For the Period
October 1 to December 31, 1959

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

Development, Testing, and Evaluation of Visual Landing Aids
October 1 to December 31, 1959

I. REPORTS ISSUED

Report No.	Title
6549	A Field Evaluation of the Relative Brightnesses of Eight Types of Runway Marking Materials
6580	Development, Testing, and Evaluation of Visual Landing Aids, Consolidated Progress Report for the Period July 1 to September 30, 1959
21P-38/59	Photometric Tests of a Preproduction Model of a Circling Guidance Light
21P-39/59	Physical and Electrical Tests of a Sample of Airport Lighting Cable
21P-42/59	Photometric Measurements of a Marine Lantern Assembly Type 2101-A1
Letter Report	Review of Drawings of Proposed Heliport Lighting System

II. VISIBILITY METERS AND THEIR APPLICATION

Shipboard Visibility Meter. A study has been made of the possibility of simplifying the proposed design of the output stages of the visibility meter circuits shown in figure 1 of NBS Report 6410. A design has been developed. Construction of a breadboard model of these stages is planned for next quarter.

Measurement of Runway Illumination and Sky Brightness. Additional measurements of the effect of the centerrow approach lights on the horizon sky brightness and illumination on a horizontal surface were obtained during this period. From a position 2300 feet from the threshold and at runway-threshold elevation with the approach lights at intensity step 5, the horizon sky brightness is greater than 50 footlamberts for nighttime conditions when the visibility is below one-half mile. These very high brightnesses may apply only to the region immediately above the lights when it is viewed from the extended runway centerline. It is not feasible to make the measurements from a position on the glidepath, but when measured from a station 2000 feet from the threshold and 100 feet from the centerline and about 20 feet below the elevation of the threshold, the horizon sky brightness was 0.6 footlambert when it was 70 footlamberts from the station on the centerline. The report on these tests will be completed during the next quarter.

Measurements of Natural Sky Brightness and Illumination. The brightness meters and illuminometers were calibrated and put back into operation. Data are now being obtained with the instruments pointing in a fixed direction. These data will be analyzed and work should be started on the report early next quarter.

Transmissometer.

Non-linear Indicator. The non-linear indicator being tested has continued to operate satisfactorily. The zero and calibration settings of this indicator are considerably more stable than they are in the regulator indicator. Preliminary tests of a number of varistors indicate that the characteristics of these varistors are sufficiently similar that they can be adjusted to the same scale.

Manual. The plates and other materials required for the rerun of the manual (NBS Report 2588) have been processed and forwarded to the Department of Commerce for reproduction. Delivery is expected early next quarter.

Errors in Transmissometer Measurements Resulting from Scattered Light. The first draft of this report is now completed except for the figures. The figures are in the process of being drawn.

Some data have been obtained using a bare lamp as the light source of the transmissometer. These data were obtained for two conditions, the first for an unshielded bare lamp and the second for the same bare lamp with approximately the bottom half of the lamp shielded. The data indicated that the error due to scattered light, in the transmissometer, is dependent on the beam spread of the light source. At a transmittance of about 0.00025 the percent error for the unshielded lamp was about four times as large as the error obtained using a transmissometer projector lamp at about the same transmittance.

There has been a slight change in the empirical equation which the data seem to fit. Last quarter it was reported to be

$$\frac{\Delta T}{T} = T^{-\frac{1}{2}} (1-T) (1-e^{-c\theta^2}).$$

After data were obtained at very low visibilities it was seen that the equation which appears to fit the data is

$$\frac{\Delta T}{T} = 4.8 \times 10^{-3} \theta T^{-1/3} (1-T)$$

where "ΔT", the increase in transmissometer reading due to scattered light, is the difference between the actual transmittance "T" and the

transmittance including scattered light,"θ", is the half angle field of view in minutes.

III. DEVELOPMENT OF AIRFIELD LIGHTING AND MARKING COMPONENTS.

Investigation of the Use of 500-watt Transformer in Marker-Light Base Assembly (TED NBS SI-5009). The light and base required for this task have not been received.

Runway Marking Materials. NBS Report 6549, A Field Evaluation of the Relative Brightnesses of Eight Types of Runway Marking Materials, was issued. This concludes the evaluation of runway marking materials conducted at Washington National Airport. However, additional measurements and observations at some future date are contemplated.

Runway Distance Markers. Some tests of the Cecil Field runway distance marker were made using photo-enlarger lamps to illuminate the sign. The brightness was increased by using four type PH/212 lamps and a single transformer over that obtained by using four standard 75-watt, 120-volt lamps, but the increase in effective range of the markers was not important. Four type PH/211 lamps were not noticeably better than the four standard 75-watt lamps. The use of six lamps does not increase the brightness of the marker although the uniformity of brightness may be slightly improved for some numerals. Type 75A lamps may be the most suitable lamp for use in these markers since they are easy to obtain. If six lamps are to be used on a single 200-watt series isolating transformer, the type 75A lamps are preferred. If greater brightness is needed for these markers, two transformers with three type 100A, 120-volt lamps, or type PH/212 lamps on each transformer will provide better brightness and better light distribution. The report for the test of these markers will be completed next quarter.

Taxiway Lighting and Marking (TED NBS SI-5007). The drawings for a proposed standard of taxiway lighting, guidance signs, and markings for Miramar Naval Air Station have been completed. One group of drawings shows the details on locations of all taxiway lights, guidance signs, and markings. Another group shows the position and legends of the taxiway guidance signs. One drawing shows the entire proposed taxiway guidance system on a map of the field. A draft of the instructions to accompany the drawings has been completed.

One major change in the operational layout of the field is proposed. It is proposed that the present taxiway across the parking apron be abandoned and peripheral taxiways be used to replace it. The total proposed system has approximately 1000 taxiway edge-marker lights, of which between 300 and 350 lights would be of the flush type for use in paved areas. On the taxiway centerline, approximately 300 "pancake" lights are needed for intersections where edge-marker lights cannot be used or cannot provide sufficient guidance. The complete taxiway lighting system may require as many as 83 taxiway guidance signs with a total of 524 sections, but only 38 of these signs with 263 sections are of major

importance and another 21 signs with 104 sections are useful but of lesser importance. The usefulness of the remaining signs depends on traffic and operational procedures. All of the lights and signs would be operated from series circuits. The proposed system will require nine 15-kilowatt constant-current regulators, to be operated at intensity steps 3, 4, and 5. This number of regulators will allow an increase in load of about three or four kilowatts on each circuit. Otherwise seven regulators could furnish the needed power for the complete system.

Observations of a commercial taxiway guidance sign have been made under various visibility conditions using several types of lamps to illuminate the sign. The sign could be read clearly and easily at 400 feet when the regulator was operated at the intensity suitable for the visibility conditions. The maximum legibility range of the sign, for high intensity in clear nighttime conditions, is between 600 and 700 feet. The legibility range of the sign in good visibility in daytime is from 350 to 500 feet.

The plans and instructions for the proposed Miramar installation will be completed early in the next quarter. This will also complete most of the work for preparing a proposed standard, but the completion of a standard on taxiway lighting and guidance signs should await reaction to the proposed Miramar installation, and, if possible, operational evaluation of the installation.

Characteristics of Series Transformers with Multiple Lamps as Loads. Tests have been completed using 60- and 75-volt lamps as loads for the 200-watt transformers as well as tests using 120-volt lamps on the 30/45-watt transformers. Figures are being prepared. The draft of the report will be completed early in the next quarter. As reported previously, there is a similarity in the curves of the 60- and 75-volt lamps and the 120-volt lamps as loads for the 200-watt transformers. The tests of the 30/45-watt transformers with 120-volt lamps show that the light output of the lamps is so low that these lamps would not serve any useful purpose for runway and taxiway lighting or marking when supplied by a transformer of this type.

Approach Beacons. The draft specification for the approach beacon is being revised and edited. Although this specification is based on the feasibility models built by the National Bureau of Standards and the drawings prepared by NAEF(SI), it is being revised so that the manufacturer

will be allowed considerable latitude in design and will not be restricted to the present design.

Maintenance Manual. There has been no progress on this task during this period. Work on this will be resumed after March 1960.

Automatic Intensity Control (TED NBS SI-5004). The design of the relay-type automatic intensity control which uses the non-linear transmissometer indicator has been completed. The required relays have been ordered but had not been received at the end of the quarter.

Heliport Lighting. Drawings of the proposed lighting system and controls for Navy heliports have been reviewed and several comments and changes have been suggested in the way of simplification. The results of the review were reported by letter of November 12.

IV. DEVELOPMENT OF SEADROME LIGHTING COMPONENTS

Seadrome Lighting Subcommittee. A meeting of the Seadrome Lighting Subcommittee of the Aviation Ground Lighting Committee, IES, was held at the National Bureau of Standards on October 2. Those attending were Mr. Hartz, Chairman (Bureau of Naval Weapons), Lt. Wesler (Coast Guard), Mr. Preston (NAS Norfolk), and Mr. R. T. Vaughan (NBS).

Transistorized Inverter for Battery-Operated Seadrome Lights. A breadboard model of a transistorized inverter for operating a 6-watt fluorescent lamp was constructed and demonstrated by personnel of Walter Kidde and Company. This inverter showed considerable promise. It was recommended that the Bureau of Naval Weapons consider the purchase of a service test lot of packaged inverters for use in tests in battery-operated seadrome lights.

Photoelectric Switch for Seadrome Lights. A new photoelectric switch is being assembled using a $3\frac{1}{2}$-inch diameter continuous strip photocell to replace the twelve individual cells in the "off" circuit, and a smaller $2\frac{1}{2}$-inch diameter cell to replace the six individual cells previously used in the "on" circuit. The advantages of continuous strip cells are increased sensitivity obtained from the greater cell area, and the simpler mechanical construction required in mounting. The circuit of this unit and the basic design were reported in NBS Report 6225.

V. DEVELOPMENT OF CARRIER LIGHTING AND MARKING COMPONENTS

Lights for Carrier Deck Personnel.

Goggle Lights (TED NBS SI-5001). Twenty sets of a feasibility model goggle light have been completed. Seven of these sets have been delivered to the Visual Landing Aids Branch for testing aboard the Ticonderoga. The remaining sets will be delivered when the lamps for the lights are received.

LSE Suit (TED NBS SI-5008). The modification of one LSO suit to a battery-powered LSE suit has been completed. (See Progress Report for previous Quarter.) The second suit will be completed upon receipt of the material requisitioned through Navy supply channels. A supply of batteries sufficient for the feasibility testing of these suits has been obtained. These batteries, type 4FL, are $1\frac{1}{2}$-volt batteries measuring 3 3/4 by 5 1/2 by 1 1/4 inches and weighing 22 ounces. Two batteries connected in parallel will be used with a suit, one carried in each hip pocket of the suit. The ampere-hour rating of a battery is 6 amp.-hrs. The current drain of a suit is 2.7 amperes. Hence the batteries are expected to give about 4 hours service if operated continuously, longer if operated intermittently.

Fouled-Deck Warning Lights for Carriers. In response to a request from the Visual Landing Aids Branch, consideration has been given to the problem of indicating a "fouled deck" to the pilot using the mirror landing system in his approach to a carrier. The use of alternately flashing red and green lights is proposed. These lights would be mounted on the top of the mirror near the "cut" lights.

The use of type 399PAR lamps is proposed. Observations made on the 750-foot outdoor photometric range indicate that a flash rate of about 90 (complete) cycles per minute is suitable. At this rate, the off periods should be about one-fifth of the on periods. A fixed voltage increase of 10 volts is required in the circuit of the green light to balance the intensities of the two lights as the intensity setting of the lights is reduced. A mechanism for flashing the lights has been designed and constructed. It is now ready for installation aboard a carrier. The mechanism consists of a motor-driven cam actuating two snap-action switches which energize two mercury relays. The cam is cut to give a sequence of 150° red, 30° off, 150° green, and 30° off. The flashing mechanism includes a transformer to provide the required 10-volt increase in the voltage of the green lamp.

VI. PHOTOMETRIC AND ELECTRICAL TESTS OF AIRFIELD AND SEADROME LIGHTING EQUIPMENT (TED NBS SI-5003).

"Night-Vision" Flood Lights. The photometric evaluation of a production-run "Night Vision Flood Light" manufactured by L. C. Doane Co. has been completed. Photometric characteristics of the light, the effects of modifications attempted at N.B.S. and suggestions for the location of lights of this type in a runway floodlighting system will be given in this report. The report has been drafted and is being prepared for reproduction.

Tests of Direct Burial Cable. A report has been issued on Physical and Electrical Tests of a Sample of Airport Lighting Cable. The cable is acceptable for use (NBS Test 21P-39/59).

Circling Guidance Light. Photometric measurements have been made of a preproduction model of a circling guidance light manufactured by A'G'A. A report giving the results of the measurements has been issued (NBS Test 21P-38/59). The beam spread of the main beams of this light was somewhat less than the spread of these beams of the light tested previously and was somewhat less than that specified in the draft specification prepared last spring. However, the performance of this light is considerably better than the requirements stated in NBS Report 4741.

Tests of Airfield Lighting Connectors. Splices were prepared using the Joy vulcanizer and these splices were buried for tests. All splices buried previously still test satisfactorily. The rainfall has been very light and the ground is still comparatively dry, so no faults have shown up. Three Scotchcast splices were prepared at Arcata and sent to Washington to be opened and checked. The splices were prepared using different methods of cleaning the cable to see if the adhesive quality of the Scotchcast compound was affected by the method used. These splices will be "seasoned" for approximately six months before they are opened.

Marine Lantern Assembly. Intensity distribution measurements were made on a "Marine Lantern Assembly Type 2101-A1" manufactured by the A'G'A Division of the Elastic Stop Nut Corporation of America. These tests were of exploratory nature to determine the applicability of the unit in aviation service. Three different lamps were employed in the tests: a 12-volt, 3.05-ampere lamp with a C-8 filament; a 1020-lumen, 6.6-ampere lamp with a C-8 filament; and a 100-watt, 115-volt lamp with a CC-8 filament. The unit performed satisfactorily in these tests. Its chief drawback is that the temperature limitation due to the acrylic plastic from which its lens is made limits lamp power to about 100 watts. The results of these measurements are reported in NBS Test Report 21P-42/59.

VII. MISCELLANEOUS TECHNICAL AND CONSULTIVE SERVICES

Standards for Runway Lighting and Marking. Technical assistance to Special Technical Group No. 14 of the National Standards Section ACC/AGA has continued in the preparation of revised drafts of the National Standards for runway and taxiway lighting and marking.

Bartow Runway Light Patent. A letter has been received from the Department of Justice stating that the patent infringement suit of the Welsbach Corporation has been settled and thanking the Bureau for the assistance given in marshalling material and making studies pertinent to the suit.

Review of Airfield Lighting, NAS Oceana. A two-day conference at NBS attended by representatives of Yards and Docks, District Public Works Office, Fifth Naval District, National Bureau of Standards, and the Visual Landing Aids Branch, Bureau of Aeronautics, was held at the request of the latter agency to review the present status of airfield lighting at NAS Oceana and to review future plans.

Paper for SAE Meeting. A paper "Some Factors Affecting Visual Range" was presented by C. A. Douglas at the meeting of SAE Committee A-20 held in Atlantic City on December 9. The paper will be issued next quarter as an NBS Report.

VIII. MISCELLANEOUS

Fog Dispersal. Air Force "Operation Pea Soup" was closed for this fog season early in this period. Because of the very limited amount of fog and the difficulties encountered in obtaining particle size and distribution measurements, there was no opportunity to correlate our observations with the results which the Cambridge Research Center obtained. This group plans to return to Arcata for further work during next fog season.

Messrs. Simeroth and Douglas have been invited to attend the fog modification planning conference to be held at Boston in January under the sponsorship of the Cambridge Research Center and to discuss the NBS work in the determination of visual range.

Weather. Following the closing of "Operation Pea Soup" an unusual number of late-season fogs which were suitable for testing enabled the NBS Field Laboratory to obtain the data required to complete a number of tasks.

Selection of Photocell for Projection Photometry. Measurements were made on six Weston Viscor photocells using red, yellow, blue, and green filters. Three filters of each color were used, one each of high, medium, and low transmittance. The best cell, from the standpoint of

spectral response, was selected. This cell was then measured for linearity of response over a wide range of illuminations (from 0.2 to 300 footcandles).

The cell selected is very good with respect to both spectral response and linearity.

Personnel. Mr. Lionel Chernoff, GS-7 physicist, entered on duty on September 28, 1959.

U.S. DEPARTMENT OF COMMERCE
Frederick H. Mueller, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its major laboratories in Washington, D.C., and Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside of the front cover.

WASHINGTON, D.C.

Electricity and Electronics. Resistance and Reactance. Electron Devices. Electrical Instruments. Magnetic Measurements. Dielectrics. Engineering Electronics. Electronic Instrumentation. Electrochemistry.

Optics and Metrology. Photometry and Colorimetry. Photographic Technology. Length. Engineering Metrology.

Heat. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology. Molecular Kinetics. Free Radicals Research.

Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Neutron Physics. Radiation Theory. Radioactivity. X-rays. High Energy Radiation. Nucleonic Instrumentation. Radiological Equipment.

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Molecular Structure and Properties of Gases. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

Mechanics. Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.

Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

Mineral Products. Engineering Ceramics. Glass. Refractories. Enameled Metals. Constitution and Microstructure.

Building Technology. Structural Engineering. Fire Protection. Air Conditioning, Heating, and Refrigeration. Floor, Roof, and Wall Coverings. Codes and Safety Standards. Heat Transfer. Concreting Materials.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

Data Processing Systems. SEAC Engineering Group. Components and Techniques. Digital Circuitry. Digital Systems. Analog Systems. Application Engineering.

• Office of Basic Instrumentation.

• Office of Weights and Measures.

BOULDER, COLORADO

Cryogenic Engineering. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

Radio Propagation Physics. Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services. Sun-Earth Relationships. VHF Research. Radio Warning Services. Airglow and Aurora. Radio Astronomy and Arctic Propagation.

Radio Propagation Engineering. Data Reduction Instrumentation. Modulation Research. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Propagation Obstacles Engineering. Radio-Meteorology. Lower Atmosphere Physics.

Radio Standards. High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Electronic Calibration Center. Microwave Physics. Microwave Circuit Standards.

Radio Communication and Systems. Low Frequency and Very Low Frequency Research. High Frequency and Very High Frequency Research. Ultra High Frequency and Super High Frequency Research. Modulation Research. Antenna Research. Navigation Systems. Systems Analysis. Field Operations.


NBS